OBSERVATIONS *on* GUN-POWDER. *By the Honourable* GEORGE NAPIER, *M.R.I.A. Communicated by the Earl of* CHARLEMONT, *P.R.I.A.*

FEBRUARY 1, 1788.

MY LORD,

IN compliance with your requeſt, I ſend you the following obſervations on gun-powder, deduced from a ſeries of experiments, in the conducting of which I was ably aſſiſted when ſuperintending the Royal Laboratory at Woolwich. Read Oct. 25, 1788.

As I do not mean to fatigue your lordſhip's attention by an elaborate pyrotechnical eſſay, I ſhall confine myſelf to ſuch facts as appeared new or intereſting in the courſe of my inveſtigation; only introducing thoſe parts of the common proceſs which may tend to elucidate an experiment, or ſerve to eſtabliſh the expediency of an alteration: To effect this with ſome degree of accuracy, I ſhall arrange my remarks under the following heads:

FIRST. The ſelection of the materials which compoſe gun-powder.

SECONDLY. The ſtrongeſt and moſt durable proportion of thoſe materials.

THIRDLY. The beſt mode of intermixing and combining them.

LASTLY, I ſhall add ſome general obſervations.

THE qualities of nitre are not eaſily aſcertained by thoſe rules which chymiſts have preſcribed for determining its purity; their deviations are frequent and ſometimes material in the compoſition of gun-powder, whoſe baſis this ſalt conſtitutes. The method I have generally adopted for detecting the impurity of nitre, is to drop a ſtrong ſolution of Sacch. Sat. into a phial of diſtilled water, ſaturated with ſalt-petre; which, if it retained any conſiderable portion of marine ſalt or magneſia, aſſumed a turbid milky appearance: The lunar ſolution is too powerful a teſt for any nitre I have met with: But it does not always follow that the pureſt nitre produces the ſtrongeſt powder: The beſt I have ſeen is the Ruſſian, yet the manufacturers in that country are not very ſolicitous about the magnitude of the cryſtals, the whiteneſs of the ſalt, nor even its freedom from heterogeneous ſubſtances, though with us thoſe qualities are accounted eſſential. In Ruſſia I am informed they ſeldom refine their nitre more than twice; and having analyzed ſome very excellent Ruſſian powder, I found the ſalt-petre contained a conſiderable portion of marine ſalt and magneſia.

magneſia. It is difficult to account for this phenomenon, as marine ſalt both impedes the ignition and leſſens the exploſion of gun-powder; and I believe it may be demonſtrated that magneſian or calcareous nitre produces at leaſt the laſt of thoſe effects, if we conſider the faintneſs of its own detonation, when it has any; and that deliqueſcent quality, which muſt communicate a degree of humidity to the compoſition, inimical to a forcible exploſion; and (what is in my opinion of much greater conſequence) which muſt be noxious in the extreme to the durability of gun-powder: I have reaſon to believe (as far as my experience can eſtabliſh the fact) that powder made with ſalt-petre, oftener than four times refined, is of inferior ſtrength, though probably more durable, than that which has been only thrice depurated: If the elaſtic and expanſive fluid contained in nitre partakes at all of a ſpirituous nature, may not repeated evaporation liberate a portion of it? *Stahl* aſſerts, that the nitrous acid is a combination of the vitriolic acid with the principle of inflammability, effected by the agency of putrefaction; and *Pietch* of the Berlin Academy ſeems to prove this theory by his experiment of moiſtening a calcareous ſtone with vitriolic acid and urine, which being expoſed for ſome time to the action of the atmoſphere, was found ſtrongly impregnated with nitre. If the aforeſaid experiment be accurate, we muſt admit that ſalt-petre is a compound ſubſtance; and it may not be a very improbable deduction to ſuppoſe that repeated elixation in part deprives this ſalt of that elaſtic fluid which conſtitutes the ſtrength of gun-powder: And this opinion is ſtrongly corroborated by two well-known facts; firſt, in purifying a large quantity of nitre there is a diſtinct deficiency of weight after the proceſs, which cannot be accounted for by the weight of the

 reſiduum;

reſiduum; and ſecondly, as great a proportion of ſalt-petre cannot be extracted from damaged powder as is obtained from ſerviceable, though originally manufactured with the ſame quantum of nitre: Perhaps, in this Ruſſian powder, the noxious qualities of the magneſia and marine ſalt were ſufficiently counteracted by the native excellence of the nitre, aided by ſome unknown ſuperiority in their method of combining and incorporating the materials.

In the choice of ſalt-petre I ſhould prefer that whoſe cryſtals are of a moderate ſize, ſolid, tranſparently white, which do not readily break with a crackling noiſe when gently graſped in the hand, and which when ignited on a red hot ſhovel do not decrepitate, but melt and conſume with an equable and continued inflammation: The firſt of thoſe ſymptoms is produced by haſty and imperfect deſiccation, and the laſt is a proof that the marine ſalt has not been entirely ſeparated from the nitre: I muſt obſerve that however carefully the proceſs of deſiccation is performed, the cryſtals will retain a certain portion of humidity (beſides their eſſential waters) which when rarefied by the heat of the hand produces a crackling noiſe; this proof of the quality of nitre muſt therefore depend on the degree of decrepitation. It may be aſked, why take ſuch pains to avoid moiſture in nitre, when its combination with the other materials of gun-powder is effected by water? I anſwer, it is this particular ſpecies of moiſture I object to, known to ſalt-petre refiners by the name of mother-waters, which taken up in the act of cryſtallization is replete with a greaſy magneſia and common ſalt. If the powder-maker refines his nitre himſelf, I adviſe him to boil it thrice, carefully ſkimming off the fœculent matter which floats on the ſurface,

and

and abſtracting the marine ſalt, which being cryſtallized by evaporation during the proceſs, falls to the bottom; let him filter it through canvas made in the form of a jelly-bag, leaving it to cryſtallize (after each elixation) in leaden or copper veſſels, expoſed to a free circulation of air in a dry ſituation, and not in a cold cellar, which is frequently, though erroneouſly, practiſed, with this palpable diſadvantage, that ſudden refrigeration forming the nitrous cryſtals before all the common ſalt has been precipitated, a part of it enters into their compoſition; they are alſo of a leſs ſize, and not ſo compact as when the ſolution is gradually cooled. It is cuſtomary with powder-makers to prefer the cakes depoſited towards the bottom of the pans in which the ſolution of ſalt-petre is ſet to cryſtallize; theſe are formed by a congeries of minute cryſtals, and are conſiderably leſs pure than the larger ſhoots, being intimately mixed with whatever heterogeneous matter the ſolution may retain, which is generally precipitated towards the commencement of cryſtallization: I ſuſpect the predilection for this kind of nitre has no better foundation than its being more readily pulverized. The mother-water which oozes from the pans is commonly ſprinkled on earth intended for generating ſalt-petre; inſtead of this, was the refiner to add to the mixture a ſmall quantity of wood-aſhes, and repeat the operation of extracting, he would find it advantageous: He will alſo ſave conſiderably by ſubſtituting iron boilers and leaden pans to his copper ones.

Charcoal affords few new obſervations. I have tried various kinds, with a ſcarce perceptible difference in their effects, provided they were completely charred and equally well pulverized; however,

however, on chymical principles, we ſhould prefer that made from wood containing the greateſt quantity of fixed ſalts, and whoſe aſhes abound with alkaline ſalts, as ſuch inflames more rapidly and burns with greater vehemence. Dogwood (cornus-fœminea, virga ſanguinea) and alder (alnus nigra, baccifera) are eſteemed by powder-makers the fitteſt for their charcoal; but I have not been able to diſcover any cogent reaſon for this preference. Green wood being harder when charred than dry, I believe admits of a more complete comminution, and is conſequently better adapted to that intimate combination of the ingredients neceſſary for the ſtrength and durability of gun-powder. I am informed of an improved method lately diſcovered for the preparation of charcoal; it is a kind of oven, which admitting the external application of heat, the wood piled within is more equally charred and its volatile parts more completely evaporated.

EXPERIENCE has convinced me that it is of the utmoſt importance to give an exact attention to the purity of ſulphur, the third ingredient in the compoſition of gun-powder. On this agent depends that rapidity of inflammation, to which the charcoal contributes intenſe fire, and the nitre its aſtoniſhing elaſticity and expanſion.

A MANUFACTURER of gun-powder ought never to uſe ſulphur which he has not purified and ſublimed himſelf: the beſt method of doing this is by melting it in an iron pot over a gentle coal fire which does not blaze, and ſtraining it through a double linen cloth; the operation muſt be repeated till there appears little or no reſiduum. When ſulphur is bought in a prepared

prepared ſtate, it is (notwithſtanding the low price) frequently adulterated with wheat-flour, which in moiſt or hot climates readily induces fermentation, and irrecoverably decompoſes the powder: I am convinced that inattention to this circumſtance is a principal cauſe of Britiſh gun-powder being leſs durable now than formerly.

THE moſt eligible proportion of the three ingredients is next to be conſidered: and here I muſt premiſe, that after an accurate examination of powder manufactured according to the moſt approved practices in Europe and Aſia, together with the numerous variations of the chymiſts, I find it beyond my experience to give a decided preference, as I have ſeen them all ſucceed and fail, changed by the qualities of the materials, or influenced by the temperature of the atmoſphere, either when the powder was manufactured and barrelled, or when it was proved. I would therefore recommend that the proprietors of powder-mills ſhould manufacture a ſmall quantity of powder from each freſh aſſortment of materials. In doing this the following canon, which is borrowed from the French pyrotechniſts, and eſtabliſhed by experiments, may be found uſeful: begin with 3 lbs. of nitre and 9 oz. of charcoal, (this will explode without ſulphur,) increaſe the quantum of charcoal till the moſt forcible combination of thoſe two ingredients is diſcovered, which will commonly happen at between 12 oz. and 1 lb. of charcoal to the 3 lbs. of nitre; to this proceſs let ſulphur be added, beginning with $\frac{1}{2}$ oz. till the ſtrongeſt exploſion is found, which will be when the proportion of this ingredient to the above is from $2\frac{3}{4}$ to $3\frac{1}{4}$ oz. Finally, let the doſe of *charcoal* be diminiſhed, till the

the compoſition no longer gains in the eprouvette; this will commonly happen when the proportions of the three materials ſtand as follows:

Nitre.	Charcoal.	Sulphur.
3 lbs.	$8\frac{1}{2}$ to $9\frac{1}{2}$ oz.	$2\frac{3}{4}$ to $3\frac{1}{4}$ oz.

The manufacturer may poſſibly diſcover ſtill greater variations than I have ſtated, as they muſt evidently be determined by the comparative excellence of his materials; but by adopting this method of aſcertaining their qualities, (however troubleſome it at firſt appears) I can venture to affirm he will in the end be a conſiderable gainer. There are various opinions reſpecting the liquid moſt eligible to moiſten the ingredients during the proceſs of preparing them for the mill: urine, vinegar, ſpirit of wine and water, plain water, have ſeverally been recommended for this purpoſe: I have tried them all without being able to eſtabliſh any data on which to found a deciſion; yet the volatile nature of ſpirits, and the heterogeneous matter to be met with in urine and vinegar, ſeem to point out a preference due to pure water; but as this is warmly conteſted, and my experiments exhibited no concluſive ſuperiority, I will not hazard a determination on the ſubject. It was my intention, in this place, to have given a formula of the ſeveral proportions in uſe amongſt the different powder-makers of Europe and Aſia, had I not been deterred by the apprehenſion of ſwelling my letter to a volume: I ſhall therefore confine myſelf to China, as that country claims the original invention, with ſome appearance of probability. Having procured ſome powder manufactured at *Canton*, I analyzed two ounces of it, and after repeating the operation ſix times, the mean reſult gave the following proportions:

Nitre.

	oz.	dwts.	grs.
Nitre, - - -	1	10	0
Charcoal, - - -	0	6	0
Sulphur, - - -	0	3	14

You will obſerve a deficiency in weight of 10 grains, probably the conſequence of ſome defect in my proceſs, which was, firſt to weigh the powder, next to ſeparate the nitre by ſolution, evaporation and filtering; I then weighed the reſiduum of charcoal and ſulphur combined; and laſtly, I ſublimed the ſulphur by a degree of heat not ſufficient to inflame the charcoal, which when weighed compleated the operation, producing the aforeſaid reſult; but as M. Beaumè, a French chymiſt, made a variety of experiments to obtain a total ſeparation of the ſulphur from the charcoal, and was never able to effect it, $\frac{1}{14}$ part remaining united, 3 grains muſt be deducted from the charcoal and added to the ſulphur to give the accurate proportion of the ingredients. This powder was unuſually large grained, not ſtrong, but I believe very durable; it had been made many years when I got it, yet there was no viſible ſymptom of decay, the grain being hard, well coloured, and though angular (which form commonly generates duſt) it was even ſized, and in perfect preſervation.

I NEXT proceed to the moſt eſſential and moſt neglected operation in manufacturing gun-powder, the combining and incorporating the ingredients. This, if poſſible, ſhould be performed in clear dry weather; a lowering ſky, and a humid atmoſphere, being found inimical to that thorough blending of the materials which ought to precede their being worked in the mill. Stamp-

ing-mills were formerly uſed for working gun-powder; their conſtruction was very ſimple, being a large mortar, in which a ponderous wooden peſtle moved by men, by horſes, or by water, performed the operation very perfectly, but with obvious danger to the workmen. In Sweden, and I believe in Ruſſia, they ſtill continue to ſtamp the powder during the firſt part of the proceſs, and afterwards roll it under ſtones; by this means leſſening the probability of an exploſion, as the compoſition is leſs inflammable in the beginning than when the materials are more intimately blended. Since government, alarmed by the frequency of accidents, thought proper to prohibit ſtamping in the ordnance mills, this part of the proceſs has been effected by means of two ſtone cylinders applied to the ends of a common axis, and moved in a vertical poſition round a circular trough, either by water or by horſes. The inferiority of the preſent practice is viſible in its operation on the powder, which has certainly degenerated both in ſtrength and durability ſince the abolition of ſtamping-mills. This may be attributed, firſt, to neglect in the manufacturer, who is ſatisfied with working his powder ſeven or eight hours inſtead of twenty-four, which was the uſual time when ſtamping-mills were employed; and, ſecondly, to a radical defect in the machine, where the circumferences of two ſmooth and ponderous ſtones compreſs the moiſt paſte into a hard ſolid cake, over which they make repeated circumvolutions with a very trifling derangement of the indurated ſurface, and conſequently without contributing much to the incorporation of the ingredients. To obviate the firſt objection, it is neceſſary that government ſhould ſtimulate the induſtry of the merchant, by giving

giving him a more liberal price for his powder, or (what would be of greater national advantage) that the board of ordnance ſhould take the management of this manufacture (as far as is requiſite for the ſupply of the army and navy) into their own hands: Whilſt it is furniſhed by contract, and the proceſs of manufacturing ſubjected to no controul on the part of government, its quality can never be depended on. Towards the cloſe of laſt war the manufacturer was paid thirty ſhillings, excluſive of eighty pounds of ſalt-petre, per barrel of powder, containing one hundred net pounds; which, conſidering the enormous price of nitre at that period, made the full coſt to the nation about five pounds. Extravagant as this may appear, when we combine the high wages of workmen, the danger of exploſion in the mills, the riſk of rejection in the proof, and, above all, the irregular dilatory mode of payment in uſe with the ordnance board, candour muſt oblige us to allow that the merchant's profit was moderate indeed. I have been informed by ſeveral of thoſe gentlemen, that they certainly could encreaſe the ſtrength and durability of their powder by milling it ſome hours longer, but that the price given would not indemnify them for the additional labour. It is ſurely unpardonable to neglect, and an ill-judged œconomy to be parſimonious in an article whoſe quality may determine the event of a conteſt, deciſive of our exiſtence as an independent people! If to this ſerious conſideration we add the expence of re-manufacturing powder, which, defective in its original conſtruction for want of ſufficient working, is returned and condemned ſoon after being iſſued (to the entire loſs of the charcoal and ſulphur) with the ſums paid for ſtore-houſes, work-

men, &c. and we may ſafely conclude that a ſmall additional expenditure in the firſt inſtance, judiciouſly applied, would turn out a very eſſential public advantage.

I WILL next ſuggeſt an alteration in the ſubſtance and conſtruction of the rollers, which may remedy ſome of thoſe defects I noted in the proceſs of *milling:* Inſtead of marble or granite, I propoſe that they ſhall be made of caſt iron, as well as the circular trough in which they move; let the periphery of the cylinder be divided into eight equal parts, alternately *grooved* and *plain*, with two of the fluted diviſions having their grooves tranſverſe, the other two longitudinal, as in the annexed drawing, where A repreſents the perſpective of the roller, and B is a plan of its circumference, ſhowing the diſpoſition of the compartments and the direction of the grooves; theſe grooves ſhould be an inch in breadth and a quarter of an inch in depth, with their angles rounded off; the trough muſt continue ſmooth, as in the preſent practice. The effect propoſed from this conſtruction is, that the alternations of the plain and fluted diviſions, when the rollers are in motion, will penetrate the ſubſtance of the paſte, producing a more intimate connexion and intermixture of the component parts than can poſſibly reſult from the equable and ſcarce interrupted progreſſion of one ſmooth ſurface over another; by this operation becoming equivalent to many hours labour. Where the private manufacturer is unwilling or unable to afford new cylinders, he may break the continuity of the paſte, by affixing a ſmall but *weighty* harrow, with copper teeth, to the axis of the roller, and following its direction in the trough. Should

iron

iron cylinders be objected to as dangerous, they may be ſhod with braſs, which will be found ſufficiently hard for this purpoſe. I muſt, however, obſerve, that the former are already uſed in ſeveral mills; and intelligent powder-makers allow, that accidental exploſions are moſt frequently produced by the colliſion of chips which break from the edges of ſtone rollers. I am aware of one plauſible objection to fluted cylinders; the paſte, if very moiſt, may adhere to the grooves; but this I think will be prevented by the application of oil to the fluted ſurfaces in ſuch ſmall quantities as ſhall not injure the compoſition.

BEFORE I diſmiſs this part of my ſubject I will hazard propoſing another alteration in the conſtruction of powder-mills; it is ſimply working four rollers in the *ſame* trough inſtead of two. Where water is the moving power, the coſt of additional mechaniſm will appear trifling, if oppoſed to the time and labour obviouſly ſaved by the adoption of this idea.

I WILL not prolong a tedious, and I fear a tireſome diſſertation, by introducing a minute detail of the proceſſes of granulating and drying powder, but content myſelf with obſerving that the firſt is performed by a horizontal wheel, on which are fixed circular ſieves, with parchment bottoms, perforated to the largeſt intended ſize of the grain; in thoſe ſieves the paſte is depoſited, and with it (in each of them) a ſmall oblate ſpherical piece of lignum-vitæ, which being moved about the ſieve by the action of the wheel, breaks the compoſition, and forces it through the parchment bottom into veſſels placed for its reception;

tion; but as this operation leaves the powder in grains of various dimenſions, it is ſorted by being paſſed through wire ſcreens of progreſſive reticulations. Powder is commonly dried in an apartment, three ſides of which are furniſhed with ledged ſhelves containing the compoſition, and the fourth is occupied by a large iron ſtove, which projects into the room, but is heated from without. This apparatus is very faulty in many reſpects, but more particularly in not diffuſing an equal heat; an amendment has been attempted, by carrying flues round the drying room, filled with heated ſteam; however the change has been little, if at all, for the better. Perhaps a circular room, with a ſpherical ſtove in the centre, might communicate a more equal degree of ſiccity to the compoſition.

I WILL next ſubmit to your lordſhip's examination ſome general obſervations, ſelected from thoſe which occurred during the courſe of my experiments on gun-powder. The powder returned by the navy and garriſons as unſerviceable was depoſited in the magazine at Purfleet, where that which ſtill retained its grain was ſeparated from the duſt; and if two drachms of it, when tried in the vertical eprouvette, had ſufficient ſtrength to project a ſuperincumbent weight of twenty-two pounds to the height of three inches and five-tenths, it was again iſſued for ſervice; but this happening very rarely, ſuggeſted a doubt, that by abſtracting the duſt, our powder was deprived of its principal ingredient; this conjecture I eſtabliſhed by repeated experiments in the vertical and mortar eprouvettes, as the duſt (though varying in degree) almoſt always exhibited ſuperior ſtrength to the granulated

lated powder from which it had been ſeparated. The phæno-menon remained to be accounted for; this was effected by an accurate examination of powder in its damaged ſtate, when with the aſſiſtance of a convex-lens I diſcovered a new cryſtallization of the nitre (called by powder-makers the ſtarting of the petre) which having been partially diſſolved, ſhot its minute ſalts to the ſurface of the grain, where they appeared like the ſpiculæ of hoar-froſt, 'till broken and detached by the attrition produced in moving the powder, they were converted into that duſt, which conſequently contained the eſſence of the compoſition. The eprouvette experiments were corroborated by the leſs fallacious teſtimony of analyzation, and this erroneous practice corrected. The foregoing obſervations muſt, however, be applied to ſuch powder only as though injured, in part retains its grain. When it is ſo far damaged as to cake, the cryſtallization of the nitre being more compleat, and its ſhootings larger, they adhere more tenaciouſly to the lumps, or when broken off are prevented by their magnitude from that intimate admixture with the ſulphur and charcoal duſt which is eſſential to forcible exploſion; all attempts to renovate powder, when thus far decompoſed, are nugatory, and can only be dictated by ignorance or fraud; it ſhould be immediately transferred to the extracting houſe. The ſtrength of new powder is not diminiſhed by reducing it to duſt, but rather increaſed, a ſecret well underſtood by powder mer-chants, who mix duſt in ſmall quantities with that powder they apprehend will not riſe to proof. It was formerly the practice of government to manufacture their powder as ſmall in the grain as that made at *Dantzick* or *Battle* is at preſent; whether the large

large corned powder now uſed merits a preference, appears to me problematical; the grain of the Chineſe powder I before-mentioned was as large as ſmall pepper-corns; and in 1782 I diſcovered at Purfleet ſome barrels of very ſmall-grained powder, manufactured by Sir Polycarpus Wharton, ſurveyor of the ordnance in Charles the Second's reign; a part of this powder was above proof, and none of it much under; the whole retained its grain, and was in compleat preſervation. It may not be improper to remark, that during the aforeſaid reign, and for ſome time after, moſt of the nitre uſed in England was collected in the country; and, if I am not miſtaken, there ſtill exiſt acts of parliament, granting the crown the ſoil of ſhambles and ſlaughter-houſes, and the earth under the flooring of ſtables, bullock-hovels, &c. and alſo directing the magiſtrates to have tubs placed in the ſtreets of populous towns, for the collection of urine: From thoſe materials there was a ſufficiency of nitre extracted to ſupply the ordinary conſumption of government. I cannot in this place omit noting the paradoxical peculiarities of this extraordinary foſſil, which, generated by a combination of animal and vegetable putrefaction, exhibits the moſt energetic antiputreſcent principles; and, though claſſed amongſt the coldeſt of the ſaline genus, is replete with vehement and irreſiſtible fire!

FORMERLY government manufactured three ſorts of powder, viz. mortar, cannon and muſquet. I am of opinion the practice ſhould be revived in part, for the following reaſon: Sulphur, by its proneneſs to fermentation, is probably the ingredient which contributes

contributes moſt to the decompoſition of powder. Believing this poſition, but retaining ſome doubts of its being practicable to produce forcible powder from nitre and charcoal only, I directed a ſmall quantity to be made, and was agreeably ſurprized to find that fifteen pounds of it projected a thirteen inch ſhell as far as the beſt powder compoſed in the uſual manner; from hence I conclude that a powder might be made ſufficiently ſtrong (when uſed in quantities *above ten pounds)* with a much leſs proportion of ſulphur than the preſent practice admits of. In caſes where a ſmaller *charge* is uſed, or where a rapid inflammation is required, the uſual doſe of ſulphur is indiſpenſably neceſſary.

THE proceſs of glazing powder is effected by attaching caſks, ſomething more than half full, to the axis of a water wheel, which turning with velocity, the operation is compleated in a ſhort time by the friction of the grains againſt each other. I found, from a mean of near *ſix hundred* experiments, that glazing powder reduces its ſtrength about one-fifth if the powder is good, and nearly a fourth if of an inferior quality; this proceſs being more noxious to the force of bad powder than of good, is accounted for, in my opinion, by the greater proportion of duſt ſeparated during the operation from the former than from the latter, as this reſiduum is invariably ſtronger than the glazed powder from which it has been ſcreened. I am confident, however, that it would be a wiſe meaſure was government to adopt the practice of glazing all high proof powder, and reſerving it for the garriſons abroad, where it muſt remain long in the maga-

zine, as powder of this deſcription retains its grain better, and is conſequently more durable, than when unglazed.

GOVERNMENT powder, manufactured at Feverſham, when received from the mills, is conſiderably ſtronger than either Dantzick or Battle ſhooting powder; and I believe it would continue ſo, was it ſecluded from the action of the atmoſphere, which might be effected by lining the barrels with the thin lead uſed for the preſervation of tea; or was it expoſed to a free circulation of dry air, according to the practice in Dutch men of war, which have an ingenious and ſafe mechaniſm for ventilating their magazines, worthy the imitation of the Britiſh navy. Frequently reverſing the barrels contributes to the preſervation of powder from that ſpecies of decompoſition induced by the different gravitation of the ingredients. In barrelling powder it is of the utmoſt importance to ſelect dry clear weather; the conſequences of inattention to this material point, have, I fear, been oftener *felt* than *ſuſpected* by our fleets and armies.

THE ſize, ſhape, and colour of the grain in powder are conſidered as indications of its quality; and though I have met with good and bad of all forms and colours, yet I am clearly of opinion that the general preference is due to powder of a moderate ſized and ſomewhat ſpherical grain, as being leaſt apt to generate duſt, which ſhould be carefully avoided, becauſe ſubverſive of that equal ſtrength which ought to be diffuſed through the whole contents of a barrel, and is in all caſes important to the efficacy of artillery, but in mortar practice becomes indiſpenſably neceſ-

ſary.

ſary. The colour ſhould be a greyiſh blue, tinged with red, and the texture of the grain firm, but not ſo hard as to reſiſt a very forcible preſſure from the finger againſt a board. I am aware that my opinion diſagrees with the general ideas of Britiſh powder-makers, who prefer a dark blue colour, and an angular grain, thinking that hue and form ſuſceptible of the readieſt inflammation; but a general deduction from numerous experiments has convinced me of their miſtake.

The ſtrength of powder is frequently impaired by being too precipitately dried; this I diſcovered on examining ſome of the rooms appropriated to that operation, where finding the heat intenſe, I ſuſpected its being ſufficiently powerful to evaporate the ſulphur, which a cloſer inſpection proved to be the caſe, as the crevices of the walls and ſhelves were filled with flour of brimſtone ſublimed by the action of the fire, from the ſurface of the grains, preciſely where the greateſt proportion of this inflammable principle is required. The acceleration of the drying proceſs has this farther diſadvantage, that it leaves the powder moiſt in the centre of the grain: I fear this practice, though every way pernicious, is become ſo general as to demand the interference of government; the detection of ſuch powder is eaſy; for when freſh from the drying-houſe it will riſe to high proof, but being left in the magazine for a month will lower its ſtrength at leaſt a fourth: And here I muſt obſerve, that in times of peace, when the demand cannot be very preſſing, powder ſhould not be proved ſooner than two months after being manufactured.

It was formerly the practice to load with large quantities of powder; and the abuſe extended ſo far, that in ordnance of a higher calibre than twelve-pounders, the charge of powder amounted to half the weight of the ſhot; the conſequence of this was, that about a fourth of the powder remained uninflamed, which added to the weight of the ball gave a reſiſtance of 27 lbs. to be overcome by 9 lbs. of powder, inſtead of 24 by 12, the ſuppoſed *reſiſtance* and *power*. To demonſtrate more accurately the abſurdity of this practice (which had been already reprobated by the beſt artillery officers) I encloſed the vertical eprouvette ſo as to prevent the eſcape of uninflamed powder, and after fifty diſcharges, in each of which 2 drachms were compreſſed by a weight of 22 lbs. I collected above a thirtieth part, or $3\frac{1}{2}$ drachms of ſtrong and highly inflammable powder. The preſent charge is a third of the ſhot's weight for heavy, and a fourth for light artillery; it would ſtill admit of reduction.

Salt of Tartar may be introduced as an auxiliary in the compoſition of gun-powder; it encreaſes the report aſtoniſhingly, but is noxious to ſtrength and durability: Government ſhould, however, give ſome attention to this matter, as a powder might be manufactured, a ſmall portion of which would produce a tremendous report, and prevent the unneceſſary expenditure of that which is ſerviceable, in the parade of war where noiſe only is required. The ſtrength of powder is by no means eſtabliſhed by the proof of the vertical eprouvette, unleſs corroborated by the braſs mortar, which I am informed is conſtantly uſed by the gentleman

gentleman who at preſent ſuperintends the manufactory and proof of government powder, from whoſe acknowledged abilities I prognoſticate conſiderable improvement in this valuable compoſition, which, though become eſſential in war, and of conſequent importance in commerce, affords ample room for melioration.

I WILL no longer treſpaſs on your lordſhip's attention, but ſubmit this paper to your entire diſpoſal, conſcious that it has more to hope from the partiality of friendſhip, than to claim from the juſtice of ſcience.

I have the honour, &c.